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Computer Assisted Cancer Device – 3D Imaging

PRINCIPAL INVESTIGATOR:
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CONTRACTING ORGANIZATION:
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14. ABSTRACT

The technical objective of the Computer Assisted Cancer Device project was to develop a platform technology that will allow for a significant improvement in the accuracy of interpreting mammograms through the use of Second Generation Computer Assisted Detection (2nd Generation CAD) that is designed for using not only the current year's screening mammograms (as is common in first generation commercial CAD) but also any additional clinically relevant information (e.g. prior mammograms, other sensors like 3D ultrasound/MRI/IR, participant history, etc.). This 2nd Generation CAD platform will be used to provide "procedure based" CAD advice to the doctors.

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Computer Assisted Cancer Device—3D Imaging
Annual Technical Report
USAMRAA Award Number: W81XWH-05-2-0039

Report Period: 1 March 2005- 31 October 2007

Principle Investigator: Albert V. Porambo, LTC, MC
Collaborators: Kevin Woods and Michael Liebman

INTRODUCTION:

The technical objective of the Computer Assisted Cancer Device project was to develop a platform technology that will allow for a significant improvement in the accuracy of interpreting mammograms through the use of Second Generation Computer Assisted Detection (2nd Generation CAD) that is designed for using not only the current year's screening mammograms (as is common in first generation commercial CAD) but also any additional clinically relevant information (e.g. prior mammograms, other sensors like 3D ultrasound/MRI/IR, participant history, etc.). This 2nd Generation CAD platform will be used to provide "procedure based" CAD advice to the doctors. This will be accomplished by adding a 3-D breast ultrasound examination to the pre-biopsy evaluation of all study participants as a way of adding additional input to the development of the CAD algorithm. Since breast ultrasound is a safe, non-invasive modality, it may be able to significantly improve the positive predictive value of breast biopsies if an algorithm can be successfully created.

It is well documented that breast cancer is frequently missed on mammograms leading to delayed detection and potentially less successful treatment. Our studies show that approximately 32% of cancers can be detected earlier in mammograms. While current CAD technology is designed to capture as many of these cancers as possible, it is not able to offer specific information in order to assist the radiologist in determining the best course of action once a suspicious region is identified. The use of additional information will allow the 2nd Generation CAD system to provide the decision support information needed for making the best decision. Approximately 4.6 billion dollars was spent conducting biopsies in 2002 and only 10-30% of these biopsies resulted in the diagnosis of breast cancer. The use of all of the available sensor and participant history data will allow the elimination of a significant number of these unnecessary biopsies and the concomitant benefit of reduced trauma and anxiety for participants who currently endure them. Breast ultrasound is a safe, non-invasive way of obtaining additional information about the participant's breasts that will be added to the other imaging modalities already in use clinically. The data will be able to be digitized and analyzed, as the 1st generation CAD does for mammograms.

We proposed to fundamentally improve the detection, diagnosis and treatment of breast cancer by developing a platform technology that will allow for a significant improvement in the accuracy of interpreting mammograms through the use of Second Generation

Computer Assisted Detection (2nd Generation CAD) that is designed for using not only the current year's screening mammograms (as is common in first generation commercial CAD) but also any additional clinically relevant information (e.g. prior exams, other sensors like 3D ultrasound/Magnetic Resonance Imaging, participant history information, etc.). Specifically in this study, 3-D ultrasound will be added to the modalities already used in the clinical care of enrolled participants. Using the additional sources of information will help move CAD technology from being a detection aid to becoming a diagnostic aid.

The overall project was expected to require 2 years with the following phases:

- Initial data collection, (please note: the only data collected will be the results of the ultrasound images identified by CBCP number) system modification and preliminary testing (12 months)
- System refinement and additional testing (6 months).
- Clinical testing (6 months).

BODY

- Award of $900,000 awarded from 3/1/05 – 2/28/06
- Modification P00001, dated 27-June-2005 extended the period of performance from 3/1/05 to 10/31/06 (Research ending 30 September 06) and increasing the funding by $1,006,484 from $900,000 to $1,906,484.
- Modification P00002, dated 07-Feb.-2006 suspended future advance payments due to lack of progress by the Awardee.
- Modification P00002, dated 11-Oct.-2006 reinstated the advance payments to the Awardee and extended the period of performance through 31 Oct 2007, with research ending 30 Sept 2007.
- A replacement Ultrasound Tech was hired in March of 2006.
- The sub award to iCAD was extended to 30 September 2007.
- Steve Worrell is no longer with iCAD
- Windber Research Institute received IRB approval on 15 December 2007 for the protocol titled; Computer Assisted Cancer Device – 3D Imaging (CACD-3D).

KEY RESEARCH ACCOMPLISHMENTS

- A total of 118 participants at Walter Reed Army Medical Center were enrolled in the CACD 3D Breast Ultrasound protocol. There was difficulty in making the US data available in the data warehouse. Accrual was terminated after the collection of 118 data sets. The collected data was placed in the data warehouse at WRI and made available to collaborating investigators and their staffs. The iCAD collaborator began data analysis.

- Initial Data Collection: Tomosynthesis data was also obtained by the iCAD collaborators for analysis in conjunction with the US data. A total of 62 sets were

collected from two of iCAD's industry partners, Siemens and GE. Each set consists of two different series of x-ray images of a breast. One series is a set of projection images, 2-D images taken at various angles. The other is a set of reconstructed "slices" through the breast which together form a 3-D volume.

- Development of Experimental Approaches: Initial research and development began with a literature review of existing papers on tomosynthesis CAD techniques. Tests on edge-preserving de-noising techniques for tomosynthesis data were evaluated for potential impact on performance. Experimental approaches for processing the 2-D projection data and the 3-D reconstruction data were developed.

  Next, a mathematical model was developed that uses the tomosynthesis geometry parameters including source position, rotation angles, step size, and gantry radius to reconstruct a 3-D model by projecting backwards from a set of 2-D projection images. This permits the calculation of an object position, like a CAD detection, in 3-D from the 2-D projection domain. This work would enable the reduction of false positives caused by overlapping dense tissue which would vary more in the different projection than a solid cancerous mass.

  An approach for tomosynthesis analysis was developed using the reconstructed slice data. Here, the current CAD algorithm for mammogram images was adapted to run on the individual slices and generate detections. Next, the detections were merged in 3-D to get volume results. True positive detections tended to persist across multiple slices (3 or more), while false positive detections usually only existed on a slice or two. This will be exploited for false positive reduction in future work.

- Creation of an Application: As part of the research effort, an application was created to analyze tomosynthesis data. The analysis included sophisticated image processing techniques to detect potential cancer regions and advanced classification methods to determine the higher probability locations. Separate classifiers were developed for each tomosynthesis manufacturer, thereby allowing for vendor-specific optimizations.

REPORTABLE OUTCOMES

No analytic research accomplishments have been made, but the there have been gains in the storage of complex data files, such as the ultrasound data that were not present in the data warehouse at the start of the study. Since this was the first foray into storage of large data files in the data warehouse regarding imaging data, this hampered this research effort, but the advances made should allow future research endeavors to proceed with less difficulty.

CONCLUSIONS

After approval of the protocol, 3D ultrasound devices were purchased for the Windber and WRAMC Sites. This was because the Windber site has digital mammography and the WRAMC site, analog or film-screen mammography, and correlation between the two modalities with respect to mammographic-sonographic correlation would be different. The WRAMC site had IRB approval first, and was first able to hire an Ultrasound technologist, who was trained on the use of the machine, but was unreliable in the performance of her duties and was dismissed. There was a significant delay in the hiring of a replacement, but eventually a competent technologist was hired who was trained in the use of the device and began enrolling study participants and performing the ultrasound scans. There was significant technical difficulty in getting the US data transferred to the data warehouse at the WRI and intermittent and little contact from the auxiliary iCAD participants. After accrual and scanning of 118 participants at the WRAMC site, the Windber site still had not received IRB approval, and enrollment was stopped to allow the Ultrasound data analysis to proceed. The transfer of the US data from WRAMC enrollees to the WRI was successfully accomplished. The iCAD team began the research purchasing mammographic data for investigation of tomosynthesis correlation with Ultrasound and was still unable to access the US data. Changes in personnel at both the WRI and iCAD led to further delays in work accomplishment, and a no-cost extension was proposed as a means to allow time for iCAD researchers to solve the access to US data problem with the assistance of the WRI personnel, but this was rejected and the study closed. General Electric 3D ultrasound devices are still located at the Windber Medical Center and the Comprehensive Breast Care Center at WRAMC.

The ultrasound data is stored in the data warehouse of the WRI and is available for future research. It is able to be correlated with the patient's demographic data, biospecimens and other imaging obtained through this and other protocols.

REFERENCES

N/A

APPENDICIES

Attachment 1: List of personnel receiving pay from the research effort.

Attachment 1:

List of Personnel
Computer Assisted Cancer Device—3D Imaging

Baskerville, Melinda	Ultrasound Technician	100%
Manning, Edward	Ultrasound Technician	100%